A WATER SUPPLY OF THE SERVICE OF SUPPLIES, A. E. F.[1]

By Jack J. Hinman, Jr.[2]

The American Embarkation Center, of which the chief town was Le Mans, extended over an irregular area which took in the cities of Nogent-le-Rotrou, Alencon, Laval, Chateau Gontier, La Fleche, Vendome, and St. Calais. It thus included all of the Department of the Sarthe and parts of the Departments of Eure-et-Loire, Orne, Mayenne, Maine-et-Loire and Loir-et-Cher. The maximum diameter was about 150 kilometers (93 miles) and the minimum diameter rather more than 100 kilometers (62 miles). Le Mans with its pre-war population of about 70,000, Laval with its 30,000 and Alencon with about 20,000 were easily the most important places in the area.

Le Mans, besides being the most important town in normal times, was the most important town to the Center. It is an important railway point on the Paris to Brest line, and it offers connections for St. Nazaire by way of Angers, for Tours by way of Chateau du Loir, and for Rouen and Le Havre by way of Alencon. In addition to these and other broad-gauge lines, there are a number of narrow-gauge departmental railways, known as *tramways à vapeur*.

It is situated at the junction of the Sarthe and Huisne rivers. The Sarthe is the larger and more important of the two and joins the Loir a short distance above Angers. The Huisne rises between Nogent-le-Rotrou and Chartres, and is followed by the Paris-Brest railroad.

The American camps in and in the outskirts of Le Mans were the Forwarding Camp, known to the French as *Camp d'Arnage*, the Classification Camp, the Belgian Camp, known also as *Camp d'Auvours*, the Spur Camp, Camp d'Etat, Maroc yards, and the

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camp at the Salvage plant at Pontlieu. There were a number of smaller camps, such as those at the Place des Jacobins, and the engineer camp on the road to Yvre-l'Eveque, as well as Base Hospital No. 52, located in the old Abbey of St. Vincent, near the Cathedral of St. Julien. The capacity of the Forwarding Camp was about 45,000 men, and the capacity of the camps named was well in excess of 100,000 men, taken all together. A large number of the officers and men of the permanent organization were billeted in the homes of the citizens, or housed in small groups, as was the case with the men assigned to the Base Laboratory, who lived in a part of a French garage in the rue Dubignon.

In connection with the Center there were eight divisional areas into which divisions were brought on their arrival in the Center. The areas were known by the name of the towns which were the headquarters of the division. Smaller towns would be brigade and regimental headquarters. One or more companies would be billeted in a village or town, according to its capacity. Each area had its camp hospital or provisions for one, and a permanent staff of area officers, town majors and military police, subsistence depots, and so on. The areas were known as the Montfort, La Ferte Bernard, Ballon, Conlie, La Suze, Sable, Chateau Gontier and Eccomoy areas. There were a number of small camps, especially of labor companies, in the forests north of Alencon, but the only camp of any size outside of the environs of Le Mans was the Holding Camp at La Suze. It will be seen from the above that the Embarkation Center had a capacity of over 300,000 men, but so far as the author knows there were never concentrated there much over 250,000.

From a water supply standpoint, the Embarkation Center was an interesting area. The water sources were most varied, ranging from the modern plants at Le Mans and Laval to springs and country wells of a very unsatisfactory sort.

The United States Engineers constructed a 500,000-gallon Roberts tub filter plant at Pontlieu to supply the Forwarding Camp and the large laundry of the Salvage plant. It used water from the Huisne river. There were wells at the Forwarding Camp (2), at the Belgian Camp (2), and at the Spur Camp (1), each equipped with chlorinators. A large manometer solution feed chlorinator was installed at the Le Mans city filter plant at l'Epau. The city water was the supply of the Spur Camp, Classification Camp, Camp Etat and Maroc yards, as well as of the troops quartered within

the city itself. The troops at La Suze were practically dependent on water filtered and chlorinated by a sterilab[3] under the charge of a first-class sergeant and a private of the Water Analysis Section.

In the small towns the local supplies and wells were used. Continual effort was made to see that the water supplied to each individual detachment was properly chlorinated before use, for, as the "Guide-Joanne" says of the region: "The water is often mediocre and one will do well to investigate its origin, to filter it with care, or to drink mineral water, if the source appears doubtful." Strange as it may seem, the two wells at the Belgian Camp, an old camp occupied at one time by Belgian troops and at another by German prisoners, were very good. Although continually being pumped dry, they showed a bacterial count below 10 per cubic centimeter on agar at 37°C., and no gas-formers in 50 cc. consistently. They were examined daily.

The amount of chlorine necessary for some of the well and stream waters was relatively very great. Usually one to two parts per million were required for a filtered water, except in the case of the Le Mans city plant. At the Le Mans plant 0.30 part per million was ample. When treating an unfiltered stream water as much as 3.5 parts per million was used at times. The above refers throughout to liquid chlorine, as the bleaching powder or hypochlorite of lime was entirely restricted to Lyster bag chlorination.

Two, three and sometimes four officers of the laboratory were kept in the field checking up the treatment of Lyster bags[4] in the various divisional areas. An attempt was made to give the officers of new units the necessary information about supplies, and to instruct the mess sergeants or other non-commissioned officers in charge of the chlorination in the proper method of treating water in Lyster bags, using the tubes of calcium hypochlorite supplied with the rations by the Quartermaster Department. All of these tubes were not of the required strength, as in addition to the errors incident to their manufacture, a variable percentage showed very fine cracks. These cracks were sufficient to allow the escape of chlorine and the entrance of moisture. When the powder in a tube was dry it was rather good evidence that the tube was in good shape, but if the powder was damp, the tube was imperfect. The discarding of such tubes was advised. In treating the water, it was desired to

[3] JOURNAL, September, 1919, page 562; November, 1919, page 635.

[4] JOURNAL, November, 1919, page 627.

leave a slight excess of chlorine, but to keep the quantity as low as consistent with good results. The reason for this was, of course, to minimize the objectionable chlorine taste.

The wells constructed by United States troops at the camps mentioned earlier were from 20 to 30 feet deep. With the exception of Well 1 at the Forwarding Camp, they were pumped by gasoline-engine-driven centrifugal pumps. The chlorinators were of the bubble meter solution feed type and gave excellent results.

The United States filter plant at Pontlieu consisted of two cylindrical wooden sedimentation tanks, 13 feet, 6 inches in diameter by 11 feet, 6 inches deep; an elevated 12,000-gallon wooden wash-water tank with drain 24 feet above ground level; a wooden filter tank, 15 feet in diameter and 7 feet deep, with circular feed trough and mechanical agitation; two wooden alum tanks, 7 feet in diameter and 6 feet deep, with the usual orifice tanks; and a rectangular concrete uncovered clear-well holding 21,000 gallons at normal level. On the effluent pipe from this clear-well was a connection to a chlorinator of the syphon-meter, solution feed type, while a second and similar machine was installed in the pump house for use in case it should become necessary to pump raw water from the River Huisne. The pumps consisted of two high-service and two low-service single-stage centrifugal pumps driven by gasoline engines. There was installed in an adjacent shed a stand-by pumping equipment of an English portable steam boiler and a duplex pump. The water was pumped through about 3000 feet of 10-inch screwed-joint pipe to the tanks at the Forwarding Camp from which it was distributed in the usual way.

The river water was somewhat highly colored and contained considerable organic matter which consumed chlorine. During the time the plant was in operation the turbidity was not very high. About 70 pounds of aluminum sulphate were used to the million gallons. The product was clear and somewhat decolorized, but required a considerable dose of chlorine to make it entirely satisfactory, on account of the chlorine-consuming substances present.

The Le Mans city water plant is interesting because it is a well-conducted modern French installation. It was commenced in 1904 after a commission had made visits to Paris, London, Antwerp, Rotterdam, Hamburg and other important places. Operation of the plant began in August, 1906. An earlier plant at the Gué (or ford) de Maulny supplied raw water from the Huisne. The present

plant is located at the Barrage de l'Epau on the Huisne about 3 kilometers (1.9 miles) from Le Mans. The plant is well constructed with attractive buildings.

In design the filter plant is a Puech-Chabal plant. The raw water is run over a series of aerating cascades and then put through a set of four roughing filters or *dégrossisseurs*. From these it proceeds to a set of ten similar units of slow sand filters, thence to a small reservoir, to which chlorine was added. The water is then elevated to a reservoir 65 meters (211.4 feet) above the plant on the hill called Gazonfier.

The total area of the roughing filters is 2500 square meters (0.51 acre). There are two sets of four elements each, 26.60 meters long (87.25 feet) and varying in depth from the coarsest to the finest from 2.25 to 2.62 meters (7 feet, 4 inches to 8 feet, 7 inches).

TABLE 1

Roughing filters of the Le Mans water works

ELEMENT	WIDTH	GRAVEL DEPTH	SIZE OF GRAVEL
1st	2.30 m. (7.54 ft.)	0.25 m. (9.85 in.)	10 to 15 mm. (0.39 to 0.59 in.)
2d	2.80 m. (9.18 ft.)	0.30 m. (11.82 in.)	7 to 10 mm. (0.28 to 0.39 in.)
3d	4.45 m. (14.60 ft.)	0.30 m. (11.82 in.)	4 to 7 mm. (0.16 to 0.28 in.)
4th	6.95 m. (24.27 ft.)	0.35 m. (13.79 in.)	3 to 4 mm. (0.12 to 0.16 in.)

The roughing filters are arranged in steps so that the water flows from one to the next under the influence of a head of a few inches. Each roughing filter is wider and uses a smaller size of gravel than the one before it (see table 1). The increase in area is intended to keep the output relatively uniform for all elements. The gravel is supported on perforated metal sheets.

When a roughing filter unit is to be cleaned, a trench is dug across one end, after draining the bed. With a powerful stream of water the gravel is shifted, so that the trench is moved across the entire length of the unit. The wash water is, of course, run to the sewer.

The distinctive feature of the Puech-Chabal plant is these roughing filters or *dégrossisseurs*. They are claimed to remove quite uniformly 50 per cent of the turbidity and 70 to 90 per cent of the bacteria from the raw water.

The effluent from the roughing filters passes to a series of uncovered slow-sand filter units. There are ten of these units each of inside measurements as follows: 27.20 by 36.40 by 2.10 meters (89.2 by 116.1 by 6.9 feet). They are set about 0.60 meter (2 feet) lower than the roughing filters. The bottom is made up of semicylindrical inverted collectors and porous blocks, supported on brick. The porous blocks are made of coarse gravel to which has been added just enough cement to hold them together firmly. The sand bed is 0.80 to 0.90 meter thick (31½ to 35½ inches). The depth of water on the sand is 1 meter (39.4 inches). The maximum rate of filtration is 2.40 cubic meters per day per square meter of filter surface (equivalent to 2,180,000 gallons per acre per day or 50.1 gallons per square foot per day). The sand used is a washed and graded river sand, of which the grains are 2 mm. and less in diameter. The output of the filters is regulated by syphon rate controllers of the Didelon type.

Cleaning the filters is done by hand in the ordinary way. Long-handled shovels and wheelbarrows are used, but the shifting of the sand outside of the filter itself is done chiefly by means of hand-operated, V-shaped dump cars. Hydraulic ejectors are not in use. In cleaning, about 2 to 3 centimeters (¾ to 1 inch) of soiled sand is removed, keeping the surface as nearly level as possible. The cleaned filter is then filled from below with filtered water and put into service.

The filters require four to ten days to ripen, according to the season and temperature. While ripening the filter is not allowed to perform its duties in the regular manner. The effluent is diverted and re-pumped to the surface of a mature filter until such time as bacteriological tests of the effluent from the newly cleaned filter show that it is performing its work satisfactorily. Once in shape to do full service, the run of the filter will be from three weeks in winter when the continual rains bring turbid waters, to three months during the summer. Finally it becomes necessary to clean the filter again. After about ten cleanings, the sand layer is reduced to about 0.25 to 0.30 meter (10 to 12 inches) and clean sand to bring the depth up to 0.80 to 0.90 meter (31.5 to 34.5 inches) must be added.

The sand washer was built in Le Mans by MM. Deschamps and Houlbert. It has two units of 3 to 3.5 cubic meters capacity per hour. It is run by an electric motor. It washes and grades the

sand and delivers it to the dump cars. The elevation of the sand to the top of the machine is accomplished by means of a small bucket conveyor for each unit.

The filter effluent passes directly to a 600-cubic meter (158,500-gallon) rectangular concrete covered clear well. It was into the inlet of this reservoir that the chlorine solution was discharged. As stated before, the chlorinator was a solution-feed machine with manometer meter and manual control.

The main reservoir on the hill Gazonfier has a capacity of 14,500 cubic meters (3,830,000 gallons). It is trapezoidal in shape, rather than rectangular, and is divided into two basins which may be operated independently or together, as they communicate by 450-millimeter gates (18 inches). The reservoir is covered, with the roof carried on pillars of reinforced concrete 0.25 meter (10 inches) in diameter, spaced 4 meters apart (13.12 feet) on centers. The walls are of masonry covered by cement. They are 5 meters (16.4 feet) high, but the water level is carried at 4 meters (13.12 feet). Two 450-millimeter (18 inches) feed lines deliver to a single chamber into which the entering water falls down a series of steps or cascades. From the entrance chamber the water flows through two 600-millimeter gates (24-inch) to the main compartments. Each chamber has a 600-millimeter (24-inch) outlet pipe. These pipes are joined, but run separately to the city.

The pumping plant includes steam, electric and hydraulic machinery. The electrically driven centrifugal pumps may derive their power from either the hydraulic plant or the steam plant through a dynamo arranged to be driven in either manner. These centrifugal pumps are used to raise the raw river water to the filter plant, while the hydraulically driven pumps and the steam pumps are employed in elevating the filtered water to the service reservoir on the hill Gazonfier. Filtered water from a newly cleaned unit in which the filter is ripening is returned to the surface of a matured filter by one of two of the centrifugal pumps.

The hydraulic plant has two undershot wheels, each with 64 curved blades 2 meters (6.56 feet) wide, according to the system Sagebien. The wheels are 8.5 meters (27.9 feet) in diameter and 5 meters wide (16.4 feet) and weigh about 50 metric tons (55.1 tons) each. The fall in the river at the dam is practically constant at 1.56 meters (5.12 feet); the speed of the wheels is controlled by gates. From 52 to 176 metric horse power is produced. At the

normal speed the wheels make 1.8 turns per minute corresponding to eight turns of the intermediate gearing and 32 complete strokes of the pumps.

There are two pumping units consisting of two pumps each. Each pump is capable of lifting 35 to 60 liters (9.24 to 15.85 gallons) per second, depending on the speed of the water wheels. The usual rate of pumpage for the hydraulic plant as a whole is 113.6 liters (300 gallons) per second, equivalent to 9821 cubic meters (2,595,000 gallons) per day of twenty-four hours.

There is also a shaft run by the No. 2 wheel which transmits power to the dynamo actuating the electric pumps. The normal speed of this shaft is 120 revolutions per minute.

The electrically operated pumps consist of four Farcot single-stage centrifugal units, each with its motor. They are located in the steam engine house, about 20 meters (65.6 feet) to the north of the hydraulic station. The two stations are separated by a canal and a pump well for filtered water which holds 350 cubic meters (92,500 gallons). The electric generator furnishing current for the pumps and the motors is a Thomson-Houston direct current machine. At 675 revolutions per minute the centrifugal pumps can each lift 66.2 liters (23.3 gallons) per second. The power required to operate the pumps varies from 8.60 to 11.1 metric horse power according as the lift from the river varies from 5.34 to 6.90 meters (17.51 to 22.6 feet).

The steam pumping engines consist of three Weyher & Richmond units. The pumps are of a type known as Meunier horizontal. The engines are run from 30 to 45 revolutions per minute according to the pumping requirements, but the normal speed is 36 revolutions per minute. The capacity of the smaller engines is 120 liters per stroke (31.7 gallons) and of the large engine 204 liters (53.9 gallons). The smaller engines can each pump from 5200 to 7800 cubic meters (1,374,000 to 2,060,000 gallons per day) while the large engine pumps from 8800 to 13,200 cubic meters (2,324,000 to 3,479,000 gallons).

The steam boilers are in two groups of three units each. Like the rest of the pumping machinery they were installed by Weyher & Richmond, of Pantin, Seine. They are horizontal fire-tube boilers, and usually operate at 6.5 kilograms per square centimeter equivalent to 92.4 pounds per square inch. The safety valve is set at 7 kilograms per square centimeter (99.6 pounds per square inch).

About 8.5 kilograms of steam per kilogram of coal of good quality is the performance claimed. There are the usual boiler feed pumps and other accessories. The boilers are hand-stoked. The brick chimney is 30 meters (98.4 feet) high.

The maximum rate of consumption for the city was calculated at 20,000 cubic meters per day (5,280,000 gallons). This seems a rather low value to Americans for a city of 70,000 people, when considering figuring maximum rate, or perhaps it would be better to say that we are accustomed to think in terms made large by the wasteful habits of the consumers. At any event, the Le Mans plant is equipped to handle water at that rate and at the same time have one centrifugal pump, one steam pump and one boiler out of service.

The plant actually produces from 8000 to 15,000 cubic meters (2,113,600 to 3,963,500 gallons) per day, with an average of 10,000 cubic meters (2,642,000 gallons).

During the time the author was in charge of the water analysis work of the American Embarkation Center at Le Mans, the laboratory checked the condition of the city water every day. The French military laboratory in the city did the same thing, and the municipal laboratory carried out more systematic investigations. All laboratories used their own media and the methods did not correspond throughout. The water was quite satisfactory according to the findings of all the laboratories, but the small amount of chlorine added by the American chlorinator was an advantage. Only about 2 pounds per million gallons were employed.

The author considers that the city of Le Mans is very fortunate in having its water purification plant operated under the direction of such capable and well-informed men as Louis Thureau, chief of operations at l'Epau plant, and A. L. Marchadier, director of the municipal laboratories.